RAND Research Brief

Meeting the Challenge of Elusive Ground Targets

Over the past several decades, U.S. aerospace forces have become increasingly skilled at detecting, recognizing, and disabling a wide range of targets, both fixed and mobile. In response to air power's growing ability to detect and defeat large ground forces in the open, the enemy is becoming increasingly elusive, operating in smaller formations and using civilian motor traffic, built-up areas, and woods to hide their activities. Recent experience in the Persian Gulf and in Kosovo has taught that these tactics are effective, particularly for long-range mobile missiles and small maneuver forces.

In research conducted for the United States Air Force and reported in *Aerospace Operations Against Elusive Ground Targets*, authors Alan Vick, Richard M. Moore, Bruce R. Pirnie, and John Stillion explore the nature of elusive ground targets to identify concepts and technologies that could improve the Air Force's capability to detect, classify, recognize, and defeat elusive targets, whether dispersed ground forces or mobile ballistic missiles. After briefly reviewing the factors that are likely to inhibit the recognition of ground targets in general, the authors use the experience of Kosovo to illustrate the challenges associated with detecting small, dispersed maneuver forces from among a host of similar objects.

Using Kosovo as its template, the report outlines new concepts that might be harnessed to defeat such forces in future operations. The authors then turn to the problem of countering mobile ballistic missiles in the context of a larger-scale conflict involving a more capable adversary such as China. They emphasize an integrated system of technologies, focused analysis, and streamlined control procedures that will enable the detect-classify-recognize-defeat cycle to occur in minutes rather than hours or days.

THE WAR OVER KOSOVO: ELUSIVE GROUND FORCES IN ACTION

Perhaps more than any other recent conflict, NATO's air war over Kosovo—designated Operation Allied Force—may offer a window into the manner in which enemy maneuver forces might continue to thwart detection in future peacekeeping operations. Both before and during this conflict, Serb forces—operating in small groups under cover of nightfall—entered villages in the province of Kosovo with the primary goal of driving ethnic Albanians from their homes. Having done so, the Serbs then dispersed, hiding in woods or intermingling with civilian populations. The result was a fleeting and highly elusive foe that, even when detected, proved difficult to attack without risking injury to civilians.

Operation Allied Force was also hindered by the manifold restrictions imposed on NATO throughout the course of the conflict. The goal of NATO's air war over Kosovo was to put an end to the persecution of ethnic Albanians. Because its motive was to stop suffering rather than inflict it, Operation Allied Force was subject to exceptionally stringent rules of engagement. As a result, the allies were forced to wage a highly constrained air campaign that favored attacks on Serbia's ground troops over the more aggressive pursuit of infrastructure targets.

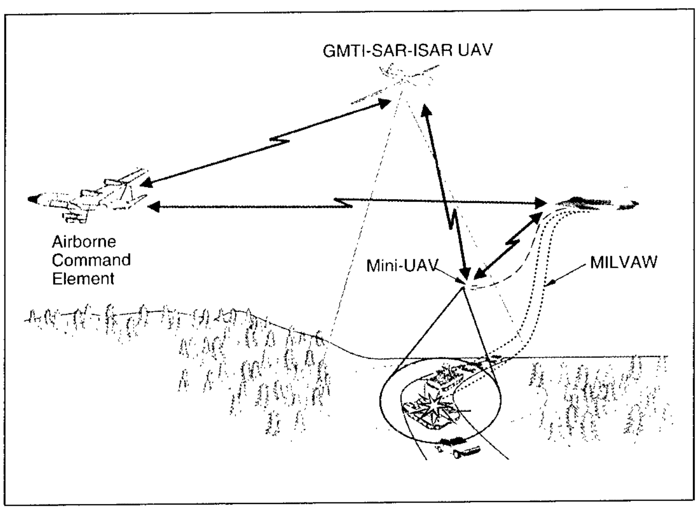
THE LESSONS OF KOSOVO: DETECTING ELUSIVE GROUND FORCES

The Challenges. Although the allies ultimately prevailed in Kosovo, the impediments they faced may well serve as object lessons for future operations. Perhaps the most pertinent of these lessons is that enemy maneuver forces may continue to elude detection even in the absence of political and operational constraints. Current wide-area surveillance radars, for example, can detect moving vehicles but have a very limited ability to distinguish military from civilian vehicles. High-resolution sensors, such as optical imagers, can distinguish tanks from trucks but have a narrow field of view and require so much human involvement that they can monitor only a small area. What is needed is a system that can monitor a large area, automatically filter out most false targets, then provide a high-resolution

image of the few remaining targets to aircrews and controllers.

Proposed Technological Responses. The engagement concepts described below bring together *finders*—assets required to identify and track enemy forces, as well as civilians who might be put at risk; *controllers*—people who direct the actions of finders and strike aircraft, select worthwhile targets, and make decisions to engage; and *strike assets*—ground-to-ground or air-to-ground weapons used to attack the targets.

Two alternative approaches are proposed for locating elusive enemy forces while they are moving. In the first approach, illustrated in the figure, a high-altitude unmanned aerial vehicle (UAV) would conduct wide-area surveillance using a radar in the ground moving-target indicator (GMTI) mode. GMTI displays all vehicles moving above a predetermined speed, providing a comprehensive picture of traffic in a large area. Automatic target recognition (ATR) software on board the UAV or an airborne control post (the Airborne Command Element in the figure) would process GMTI returns to filter out signatures of nonmilitary targets. The remaining potential targets would be imaged with a synthetic aperture radar (SAR) for stationary targets or inverse synthetic aperture radar (ISAR) for moving targets. ATR software would be used to analyze these images, further reducing the number of images that controllers would have to view.



UAV Views Moving Ground Targets

Engagement controllers on board an airborne command post would validate and correlate the remaining SAR or ISAR images with areas of suspected activity and areas of particular concern. For targets that appear valid, they would then request that a combat aircraft in the area drop a small UAV. The UAV would orbit the targets at low altitude, relaying high-resolution images to the combat aircraft and airborne command post. Together, the controllers and strike aircraft crew would assess risks and constraints and decide to engage the target. The controller would then authorize the attack, which would be carried out by a combat aircraft using a MILVAW (a Man-In-the-Loop Variable-autonomy Anti-armor Weapon), as shown in the figure.

As a supplement or alternative to this approach, air-inserted, unattended ground sensors could harness a variety of detection methodologies to identify enemy military vehicles while they are traveling. Seismic sensors could detect the vibrations of such vehicles, thereby confirming that the vehicles are in motion. Acoustic sensors could then isolate the fundamental frequency and harmonics of a motorized vehicle to generate a unique acoustic signature that could be compared to a database of signatures via automatic target recognition technology.

The Need for Pre-Battle Analysis and Control. Although new technologies are necessary, they alone cannot solve this problem. Rather, it is the combination of pre-battle analysis, new technologies, and streamlined control that offers the potential to improve U.S. capabilities against elusive targets dramatically. For these approaches to be effective, U.S. joint forces will need a better understanding of the adversary's tactics and procedures, the limitations of the adversary's equipment, and the physical and social environment. Surveillance and intelligence collection can then be focused on the most promising areas and times. For Kosovo, such pre-battle analysis would have identified those geographic features that Yugoslav forces would have had to dominate to maintain control over their province, where Yugoslav forces in Kosovo would likely have deployed, and expected electronic signatures.

DEFEATING MOBILE MISSILES: A BROADER SCENARIO

Yet another potentially elusive target set may be found in long-range mobile missiles, particularly those operating within enemy territory. During the Gulf War, mobile SCUD missiles aimed at Israel and Saudi Arabia came out of hiding to level their attacks from deep within the sanctuary of the Iraqi desert. Once having done so, they continued to move to avert detection by allied aircraft. Such weapons would present an even more potent threat in the hands of a major power such as China. Operations against Chinese missile forces would be daunting because of the potentially vast areas they might hide in, the millions of civilian motor vehicles that could confuse sensors, and the advanced air defenses that the Chinese are currently developing and deploying.

To find and destroy a mobile missile launcher during the launch phase, the authors propose a multistep process that would begin with cuing from space-based infrared

satellites. Once a missile launch had been detected, the rough coordinates of the launch would be sent to a controller. The controller would then authorize a bomber or other aircraft on patrol outside Chinese airspace to launch a hypersonic weapon. This weapon, traveling at eight times the speed of sound, would fly toward the coordinates. Meanwhile, the controller would direct a space-based radar satellite to monitor the launch area with GMTI and SAR. The GMTI mode would detect any movement of the launch vehicle, and the SAR would produce images to assist in targeting. When the hypersonic weapon neared the launch area, it would go into a high-G turn to lose speed, then deploy four autonomous anti-armor weapons that would fly search patterns in the immediate vicinity. Once the launch vehicle or vehicles were found, they would be destroyed by self-forging fragment warheads.

A similar strategy could be used to detect and destroy mobile missile launchers while they are moving. In the absence of a launch signature, GMTI radars on board satellites or stealthy UAVs would constantly monitor Chinese roads, using ATR software to filter out all vehicles except those with the dimensions of missile-launching vehicles. Such vehicles would be imaged with an ISAR or SAR. ATR software would again be used to filter out those that did not match the template. Finally, the remaining images would be sent to controllers for their evaluation. Since the rules of engagement are likely to be less strict in such a conflict, additional verification with visual-spectrum imagery would probably not be required. Rather, the controller would authorize launch of hypersonic weapons. These weapons would receive in-flight updates as the GMTI radar tracked the target. In the final phase, the target would be detected and destroyed by the autonomous anti-armor weapons as described above.

NEXT STEPS FOR THE UNITED STATES AIR FORCE

Although it is difficult to predict the precise role that elusive ground forces will play in future conflicts, it seems likely that such targets will become an increasingly prominent feature of the modern battleground. For aerospace forces to detect and destroy elusive forces systematically, they will need to do four things quite rapidly:

- Conduct wide-area surveillance of enemy operating areas.
- Automatically filter out a high percentage of false targets.
- Get a high-resolution picture of remaining suspected targets into the hands of a controller with the authority to order strikes.
- Put strike assets on the targets before those targets evade observation.

Current forces can do some of these things and, under the right conditions, are likely to be successful against some elusive targets. However, they cannot routinely detect, identify, and destroy such targets. Without this ability, U.S. operational and strategic goals—for example, preventing ethnic cleansing or defending an ally from heavy missile attack—are unlikely to be met. Thus, new technologies, concepts, and procedures will be necessary to gain an edge on elusive targets.

The authors recommend that the United States Air Force take the lead in identifying and testing the most promising technologies and concepts. GMTI and SAR ATR software, air-dropped UAVs, air-dropped ground sensors, hypersonic weapons, and small autonomous or semi-autonomous weapons are all representative of the types of technologies that will need to be developed to solve this problem.

This research brief describes work done for RAND's Project AIR FORCE; it is documented in Aerospace Operations Against Elusive Ground Targets *by Alan Vick, Richard M. Moore, Bruce R. Pirnie, and John Stillion, MR-1398-AF, 2001, 179 pp., ISBN 0-8330-3051-5, available from RAND Distribution Services (Telephone: 310-451-7002; toll free 877-584-8642; FAX: 310-451-6915; or email: order@rand.org). Abstracts of RAND documents may be viewed at www.rand.org. Publications are distributed to the trade by NBN. RAND® is a registered trademark. RAND is a nonprofit institution that helps improve policy and decisionmaking through research and analysis; its publications do not necessarily reflect the opinions or policies of its research sponsors.*

RAND

1700 Main Street, P.O. Box 2138, Santa Monica, California 90407-2138 • Telephone 310-393-0411 • FAX 310-393-4818
1200 South Hayes Street, Arlington, Virginia 22202-5050 • Telephone 703-413-1100 • FAX 703-413-8111
201 North Craig Street, Suite 102, Pittsburgh, Pennsylvania 15213-1516 • Telephone 412-683-2300 • FAX 412-683-2800

RB-76-1-AF (2002)